Polar Biogeochemistry: Modeling Tracer Transport in Sea Ice

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Abstract

The highest algal concentrations in oceanic polar regions occur in sea ice. This important source of primary production, formerly neglected in coupled climate system models, plays a multifaceted role in the high latitudes through ecosystem dynamics, cloud formation and, potentially, sea ice evolution. Arctic ice bottom or "skeletal" layer algal models have been developed which exploit the link between sea ice extent and thickness and algal growth. However, these models say nothing of internal ice or surface ice algal communities which can dominate production in the Southern Ocean or regionally under varying sea ice evolution histories. This work concerns the first stage in the development of a vertically resolved ice algal model: a model of nutrient transport through sea ice. The transport equation depends on sea ice microstructure and evolution history, information obtained or diagnosed from CICE (the LANL sea ice model). Some preliminary numerical results are presented.

1 Results

We use CICE to model growing sea ice in typical Arctic winter conditions with constant tracer concentration (nitrate) in the ocean waters. Daily averaged vertical profiles are plotted over 2, 12 and 31 day periods. Temperature profiles are prognosed by CICE but salinity is fixed and has an assumed vertical profile. In the figures below, we compare results given a typical August salinity profile ('AUG') with a typical winter profile ('Dec'). Our transport equation and diffusivity depend on sea ice porosity, permeability and brine density.

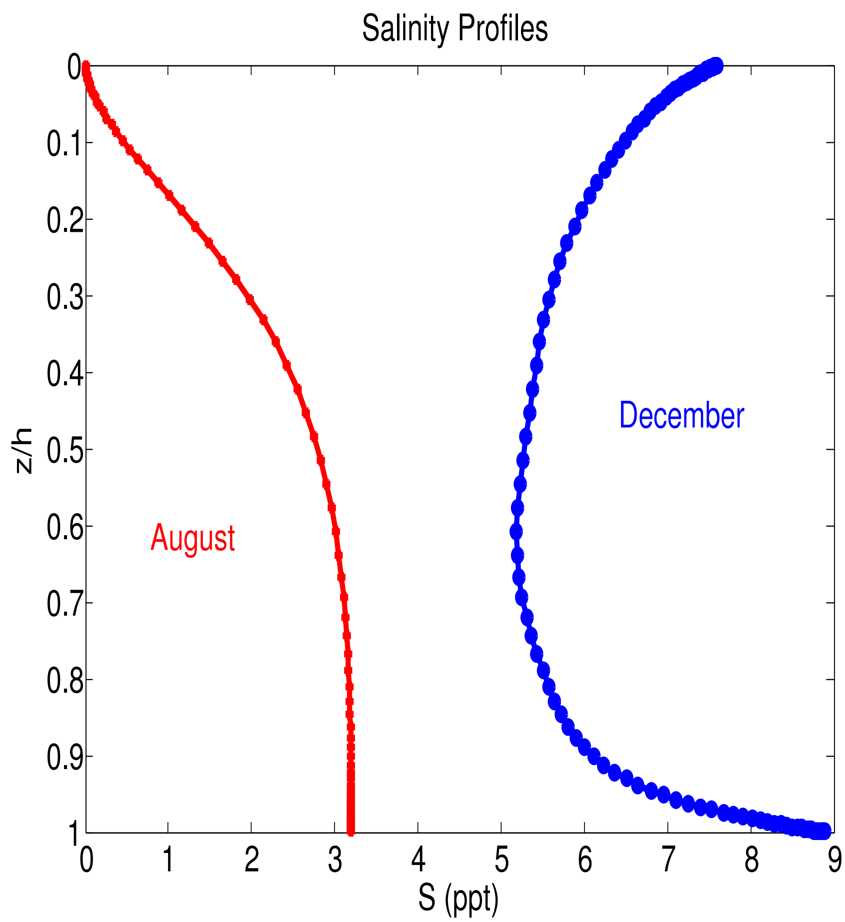

Figure 1: Contours of bulk salinity profiles in sea ice. The red countour ('Aug') is typical of multi-year or late season ice after brine expulsion and gravity drainage has reduced total salinity, and the blue contour ('Dec') is typical of early first year sea ice.

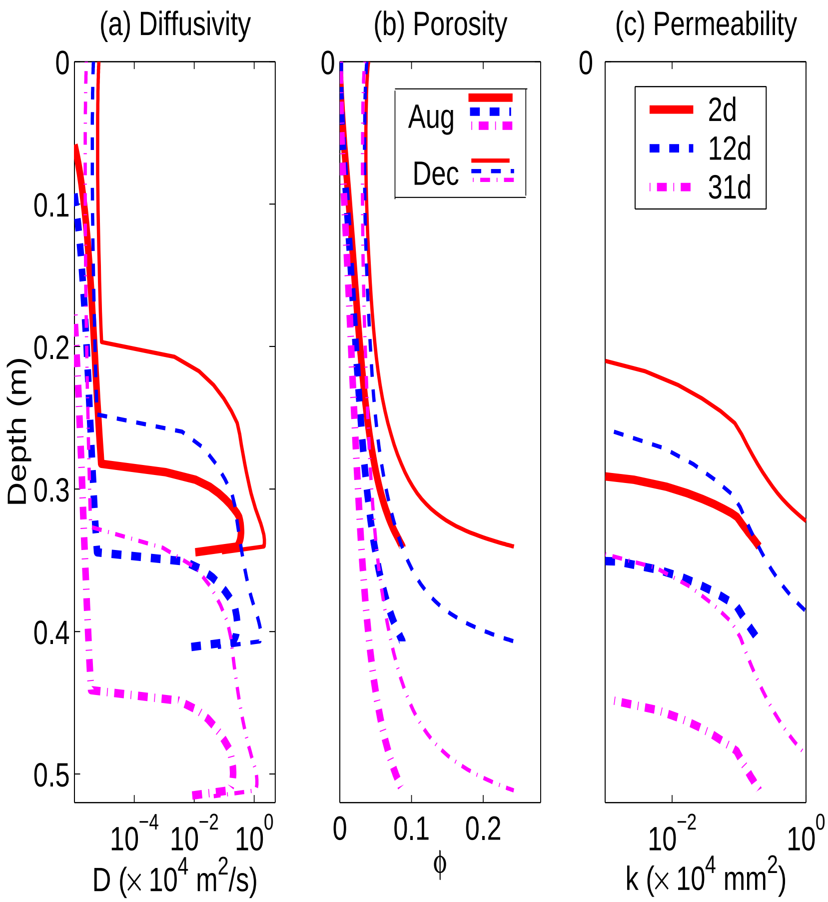

Figure 2: Vertical in ice profiles of our modelled diffusivity as a function of sea ice porosity and permeability for two fixed salinity profiles ('Aug' and 'Dec'). Results are plotted during sea ice growth with constant air and sea temperature at day 2, 12 and 31.

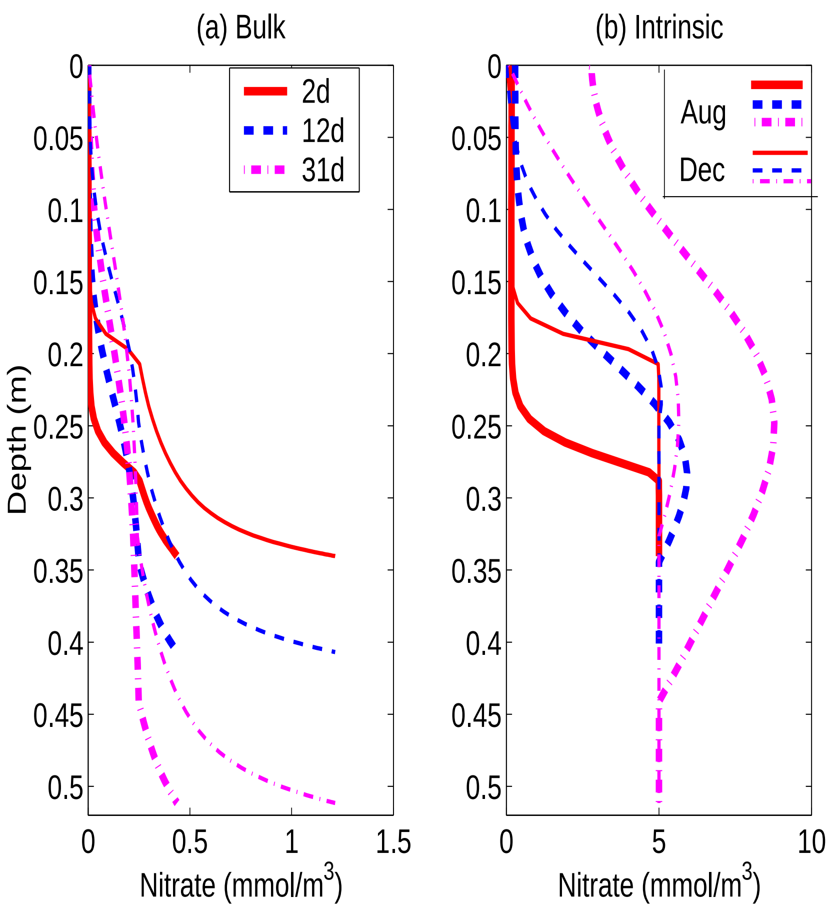

Figure 3: A constant source of oceanic nitrate was assumed during sea ice growth under the same conditions as figure 2. Vertical in ice profiles of the total (bulk) nitrate concentration (left figure) and the brine (intrinsic) nitrate concentration (right figure) are plotted. Results compare nutrient transport under differing ice salinity profiles.